"Literature adds to the reality, it does not simply describe it. It enriches the necessary competencies that daily life requires and provides; and in this respect, it irrigates the deserts that our lives have already become”

C.S. Lewis

The literature review is a critical discussion and summary of statistical literature that is of ‘general’ and ‘specified’ relevance to the particular area and topic of research problem. The literature review is important not only because it describes how the proposed research is related to prior research but it also appraises, encapsulates, compares and contrasts, and correlates various scholarly books, research articles, and other relevant sources that are directly related to the research. It shows the originality and relevance of the research problem, specifically how the research is different from other researches. It helps in identifying new ways to interpret, and shed light on any gaps in previous research. It provides an impression about the important aspects of the topic. It also helps in justifying the proposed methodology as well as gives an insight to the methods used in the previous researches. Therefore in this chapter, a detailed account of researches related to air ions has been presented.

Several experimental human studies on air ion exposure and other variables have been published throughout the century but the studies conducted on its effect on attention are virtually lacking. A structured literature review was performed on the physiological or psychological health effects attributed to air ions. Various journals, dissertations, books were consulted for this purpose. To update and supplement these earlier studies, a literature search using the Medline (PubMed) bibliographic database was conducted to identify articles on air ionization and depression, anxiety, mood states, subjective feelings of mental well-being, physiological conditions, and cognitive performances etc. in humans. ProQuest DIALOG was used to retrieve studies from the environmental and behavioral sciences, engineering, and other technical databases, including Elsevier, Medline, Science direct, Biobase, and Embase. Identical search strings for PubMed and ProQuest DIALOG, referenced the exposure of air ions (air ions, charged aerosols, corona ions, atmospheric ions, ionization, ionized air, heavy ions, light ions) and outcomes of interest (learning, memory, depression, anxiety, mood,
activation, personal comfort, relaxation, sleepiness respiration, asthma, lung cancer, chronic obstructive pulmonary disease, allergy, or rhinitis). Research papers were also collected from National Medical Library, New Delhi.

To deeply probe and understand its mechanism, it was decided to summarize studies conducted on air ions and attention. In the following sections, the studies related to physiological correlates would be reviewed, followed by the studies related to psychological variables such as anxiety, depression, mood, stress, learning, memory etc.

Earliest evidences of negative air ions are found in ancient Yoga books in which it is prescribed to perform yoga activities in a cave or near waterfalls or in a cave under a waterfall. Because a cave or waterfall is rich in negative air ion energy. Perhaps the ancient generation did not know much about negative air ions but due to their experiences they could certainly sense something in the form of such air being more energetic.

This section covers the studies related to air ions and its effect on various physiological measures. Studies that reported the association between ionization and metabolism, blood pressure, heart rate, pulse rate etc are covered in the following section followed by the studies related to its effect on chemical changes in the body. After that the studies related to respiratory and asthmatic problems are covered up.

Yaglou, Brandt, and Benjamin (1933) performed an experimental study to evaluate metabolic changes (total metabolism, pulse rate, blood pressure, body temperature) during exposure to positive or negative air ions in 60 subjects (25 females and 35 males, age range: 10–68 years) under basal and routine dietary conditions. The study found comparable changes between positive and negative air ion exposure despite the concentration level used, and no noteworthy metabolic alterations attributable to ionization were identified.

Silverman and Kornbleuh (1957) conducted an experiment to examine the effect of negative and positive air ionization on the human electroencephalogram. Ten healthy adults and two subjects with chronic stationary neurologic conditions participated in the study. Findings indicated a consistent decrease in alpha activity, a non-specific response, ranging from 0.5 to 1.5 cycle decrements during negative or positive air ionization, or both, in 10 subjects (9 healthy; 1 neurologically impaired). More than half of their 12 subjects reported one or more
symptoms of dryness of the mouth/upper respiratory tract, relaxation, or sleepiness when exposed to either negative or positive air ionization; however, these responses were more prevalent during negative air ionization.

In a subsequent experimental study conducted by Yaglou (1961), 25 healthy adults (17 males and 8 females, age range: 22–51 years) were exposed to positive or negative air ions for 1 to 2 hours in between pre- and post-test control periods. A single-blind crossover study was conducted to examine the effects of negative and positive air ionization on relaxation. In the first study of 25 adults, 5% reported feeling relaxed when exposed to positive air ions; 17% reported feeling relaxed when exposed to negative air ions; and 21% reported feeling relaxed under control conditions (1961). No significant differences in subjects’ metabolic rate, blood pressure, oral temperature, and red and white blood cell counts were found. The authors also conducted an experiment in six arthritic adult patients exposed to positive or negative air ions and observed no major changes in metabolism, heart rate, and blood pressure, except in anxious patients experiencing air ion treatment for the first time. In addition, they examined if negative air ion therapy was beneficial to the growth and development of five infants, and found that babies’ weight gain, heart rate, and body temperatures did not significantly change when exposed for 2 hours during a 2 week ionization period compared to non-ionization periods. In this study, a higher frequency of patients reported feeling relaxed or sleepy, or both, when exposed to negative versus positive air ions.

Lambert, Olivereau, and Tuong-Nagoc (1981) measured EEG hippocampal theta frequency and amplitude and EEG cortex-frontal amplitude and occipital amplitude in 18 rats. A dose level of 8.0x10^4 ions/cm^3 of both polarities was given for three weeks. An independent three group design was used. One group received positive air ions, the other received negative ions and a third group served as control. Electrostatic precipitation of large particle with proper ventilated cage was used as air-delivery system. Results were analyzed by t-test. The electrocortico-graphic study on rats showed a significant decrease in ‘theta-hippocampic rhythm’ and an increase in overall amplitude with positively ionized air. This was interpreted as an indication of lowered brain arousal or a decrease in vigilance. Negative air ions induced more intricate effects i.e. brain excitability was lowered when tested with weak stimulations, but normal when evaluated with medium high level stimulations.
Inbar, Rotstien, Dlin, Dotan and Sulman (1982) investigated the effects of negative air-ions on human physical performance. The study was conducted on twenty-one healthy males, 20–25 years old (X=23.6±2.6). Subjects were exposed to two 180-min rest and exercise sessions two weeks apart. The subjects were randomly assigned into either an experimental group (n=12) or to a control group (n=9). The experimental group performed the first session in neutral air conditions and the second one in air containing 1.36 to 1.90×10^5 negative air ions and 1.40 to 1.66×10^2 positive air ions/ml. The control group performed both sessions under neutral air conditions. All sessions were held at T_a=40±1°C and 25±5% RH. Each session included one hour of resting under the respective ionization conditions, followed by 3 30-min cycle ergometer work bouts, separated by 7-min rest periods. The mechanical work-load during the bicycle exercise was 1.64±0.6 W/kg BW. Results were analysed by using t-test. The experimental group showed a significant reduction with negative air-ions in heart rate (HR), in rectal temperature, and in the rating of perceived exertion (RPE), all when compared with their own neutral session. The control group showed no significant changes between the first and the second exposure. Although not statistically significant, being exposed to negative air-ions seems also to reduce total sweat rate and minute ventilation (V_E), and to increase O_2 pulse.

Baron (1987) consecutively conducted studies to investigate the impact of negative air ions on interpersonal attraction. In Study 1, female subjects received information suggesting either that a stranger (a female accomplice) shared their attitudes and evaluated them positively or that a stranger did not share their attitudes and evaluated them negatively. They did it in the presence of a low (ambient) or high level of negative ions. On the basis of previous research, it was predicted that a high level of negative ions would intensify subjects' reactions to the stranger, thus enhancing their evaluations of her when she seemed to share their attitudes and to like them, but reducing these evaluations when she did not share their attitudes and disliked them. Results offered support for these predictions. In Study 2, female subjects performed two tasks (letter and digit copying) in the presence of a low or high concentration of negative ions. Their blood pressure and pulse were measured at several points during the experiment. Results indicated that on various trials both systolic and diastolic blood pressure were higher in the high-ions than in the low-ions condition. In addition, subjects reported higher levels of subjective arousal and made significantly more errors on the letter-copying task in the presence of a high concentration of negative ions. Together, the results of these studies were interpreted as offering support for the view that high concentrations of negative ions can increase both physiological and psychological (subjective) arousal.
In a cross-over experiment conducted by Reilly and Stevenson (1993), oxygen uptake (VO₂) and minute ventilation (VE), rectal temperature (Tr), heart rate (HR), and anxiety levels were examined in eight healthy adult males (age range: 19–25 years) exposed to negative air ions. Exposures at 4 different times of day (01:30, 10:00, 14:00 and 18:00 hour) were presented to subjects under experimental and control conditions. Measurements were taken both at rest and during two consecutive 20-minute sessions of physical activity. Results indicated that negative air ions significantly reduced resting values of all physiological variables (p between 0.05 and 0.01): these effects tended to disappear under exercise conditions, except for Tr. The authors observed a significant reduction in mean VO₂ levels and VE between non-ionized and ionized conditions in resting subjects. In contrast, no significant impact of air ions on VO₂ levels and VE were identified during physical activity. When the authors examined differences between conditions in the delta (exercise minus rest) values of these outcomes, a significant elevation in both VO₂ levels and VE was noted in the ionized compared to non-ionized conditions. Along with this showed no significant effect of air ions on state anxiety pre- or post-exercise. Results confirm that negative air ions are biologically active and that they do affect the body's circadian rhythmicity.

Kosenko, Kaminsky, Stavrovskaya, Sirota, and Kondrashova (1997) conducted a research at the Institute of Theoretical and Experimental Biophysics of the Russian Academy of Sciences, in Pushchino, Russia. The device generated 1 200 000 light negative charges at the point of application 1.2 m acid lustre. They found that exposure to negative ions increased levels of the protective antioxidant enzyme superoxide dismutase (SOD) in mammalian erythrocytes. 0.5–1.0 microM H2O2 was found in incubation medium after treatment with air ions. The researchers also discovered minute amounts of H2O2 (hydrogen peroxide), writing, “The primary physiochemical mechanism of beneficial biological action of negative air ions is suggested to be related to the stimulation of superoxide dismutase activity by micromolar concentrations of H2O2 (hydrogen peroxide).”

Watanabe, Noro, Ohtsuka, Mano, and Agishi, (1997) conducted a single-blind study. The study was conducted on 13 healthy adults (12 males and 1 female) between an age range of 21–49 with mean age 26.4, under two conditions; experimental and controlled. The physical effects of negative air ions on humans were determined in an experimental sauna room equipped with an ionizer. Thirteen healthy persons took a wet sauna bath (dry bulb
temperature 42 degrees C, relative humidity 100%, 10 min exposure) with or without negative air ions. The subjects were not told when they were being exposed to negative air ions. Results were analysed by t-test and chi square and observed no significant difference in reported mood states changes in their blood pressures between experimental and control conditions. The surface temperatures of the foreheads, hands, and legs in the sauna with negative ions were significantly higher than those in the sauna without ions. The pulse rates and sweat produced in the sauna with ions were significantly higher than those in the sauna without ions. The results suggest that negative ions may amplify the effects on humans of the sauna.

Kondrashove, Grigorenko, Tikhonov and Sirota (2000) studied the primary chemical mechanism of the beneficial medical/biological action of negative air ions. The superoxide anion $O_2^-$ was detected in the flow of negative air ions generated by an electroeffluvial air ionizer. Earlier, the appearance of hydrogen peroxide in solutions treated with air ions was shown. The presence of these reactive oxygen species in ultralow and low concentrations ($10^{-12}$-10$^{-6}$ M) suggested that the primary mechanism for the beneficial medical/biological action of negative air ions is moderate activation of free radical peroxidative oxidation within a physiological range that is lower than in tissues under pathology. It was shown in patients that treatment with inhalation of negative air ions did not induce pathological changes in superoxide dismutase activity and, under simultaneous administration of a food antioxidant, led to its fluid increase. They concluded that better results for medical treatment can be achieved with ionized air.

Suzuki, Yanagita, Amemiy, Kato, Kubota, Ryushi, Kita (2008) examined the effects of NAI on physiological responses, such as blood pressure (BP), heart rate (HR), and heart rate variability (HRV) as well as neuronal activity, in the paraventricular nucleus of the hypothalamus (PVN), locus coeruleus (LC), nucleus ambiguus (NA), and nucleus of the solitary tract (NTS) with c-Fos immunohistochemistry in anesthetized, spontaneously breathing rats. In addition, cervical vagotomy to reveal the afferent pathway involved in mediating the effects of NAI on autonomic regulation was also performed. Adult male Wistar rats were used for the experiment. The rats were caged in groups of 3-4 under controlled temperature (23-25°C, 45-50% humidity) and lighting with ad libitum access to food and water. Surgical procedures were used to place catheters. The anesthetized animals were exposed to 5000-8000 negative ions/cm$^3$ or normal air. Results were analysed by F-test and signifies that NAI significantly decreased BP and HR, and increased HF power of the HRV
spectrum. Significant decreases in c-Fos positive nuclei in the PVN and LC, and enhancement of c-Fos expression in the NA and NTS were induced by NAI but after vagotomy, these physiological and neuronal responses to NAI were not observed. These findings suggest that NAI can modulate autonomic regulation through inhibition of neuronal activity in PVN and LC as well as activation of NA neurons, and that these effects of NAI might be mediated via the vagus nerves.

Nimmerichter, Holdhaus, Mehnen, Vidotto, Loidl, and Barker (2014) conducted a study to test the physiological effects of negatively charged air ions. 14 trained males (age: 25-39 years) were exposed for 20 min to either a high-concentration of air ions or normal room conditions in an ionization chamber in a double-blinded, randomized order, prior to performing: (1) a bout of severe-intensity cycling exercise for determining the time constant of the phase II response (τ) and the magnitude of the slow component (SC); and (2) a 30-s Wingate test that was preceded by three 30-s Wingate tests to measure plasma [adrenaline] (ADR), [nor-adrenaline] (N-ADR) and blood [lactate] (B_lac) over 20 min during recovery in the ionization chamber. Results were analysed by A two-factorial mixed ANOVA and indicated no difference between ION and PLA for the phase II or SC. No differences between ION and PLA were observed for ADR, N-ADR and B_lac as well as on peak and mean power output during the Wingate tests (all P > 0.05). A high-concentration of negatively charged air ions had no effect on aerobic metabolism during severe-intensity exercise or on performance or the recovery of the adrenergic and metabolic responses after repeated-sprint exercise in trained athletes.

This surfeit of negative ions has long been associated with improvements in physical health. Research conducted in the last decade has begun to support the view that negative ions have a net positive effect on physiological health. Although some studies have concluded that negative air ions do not have any effect on various physiological measures such as heart rate, blood pressure pulse rate etc but others have reported a positive effect of negative air ions exposure. Following section reviewed the studies related to effect of air ions on chemical levels in the body.

Krueger and Reed, (1976) conducted a study and measured metabolic changes in mice and rats in response to changes in ion charge (negative or positive) and concentration, including alterations in serotonin levels and recovery from illness. When subjects were exposed to negative ions, a considerable increment in the amount of 5-hydroxyindoleacetic was
observed. Negative ions lower tissue levels of 5-HT by accelerating this enzymatic oxidation process. When subjects were exposed to positive ions (which accumulate in the atmosphere at the beginning of a storm) it was noted that animals became agitated, aggressive and were more prone to respiratory illness. Furthermore, when mice were infected with influenza virus and housed in an environment depleted of all ions, death rates increased, indicating a previously unknown benefit on overall health.

Sulman, Levy, Lunkan, Pfeifer and Tal, (1978) studied the absence of harmful effects of protracted negative air ionisation in 5 weather-sensitive women and 5 normal men chosen at random. The patients were exposed separately during 8 sleeping hours and 8 working hours to the apparatus at 1–2 m distance in a 4 × 4 m room, for 2 months. Thus they were exposed to a daily uptake of $1 \times 10^4$ negative ions/cm$^3$ for 16 h/day during 2 months. Results were analysed by t-test and found that Urinary 17-KS, 17-OH, adrenaline and noradrenaline excretion was not affected by the negative ionisation. However serotonin, 5-HIAA, histamine and thyroxine excretion — if increased before — diminished by 50% on an average. There were no changes in body weight, blood pressure, pulse, respiratory rate, oral morning temperature, dynamometer grip strength, routine liver function tests, urinary pH, albumen, glucose, ketones, bilirubin, or occult blood, red and white blood count and ECG records. The EEG revealed the typical changes due to negative air ionisation: stabilising of frequency, increased amplitudes, spreading of brainwaves from the perceptive occipital area to the concepitive frontal area and synchronisation of both hemisphere tracings.

Sulman (1980) measured the impact of atmospheric electricity on human subjects by monitoring daily changes in urine excretion of neurohormones in samples gathered from 1,000 volunteers exposed to positive ions generated 1 to 2 days prior to the arrival of a storm front. By measuring the changing levels of neurohormones in the 24-hour urinary output of the subjects during normal and weather-stress days, the researchers compiled a profile of changes in levels of serotonin, 5-HIAA (5-hydroxyindole acetic acid, a serotonin metabolite), adrenaline, noradrenaline, histamine and thyroxine. The researchers found that the electrical charges (positive ionization) engendered by every incoming weather front produce a release of serotonin. They further identified three classes of weather sensitivity reactions: a) serotonin hyperproduction causing a typical irritation syndrome; b) adrenal deficiency producing a typical exhaustion syndrome; c) hyperthyroidism with subclinical ‘apathetic’ thyroid symptoms. Noting that these conditions occur during annual wind storms (Sirocco,
Sharav and Santa Ana winds), the authors stated that the effects, “which are mainly due to positive ionization of the air,” could be “prevented by negative ionizing apparatuses or specific drug treatment.” (Sulman, Levy, Lunkan, Pfeifer, Tal, 1977).

Udermann and Fische (1982) conducted a study and given the evidence of the influence of ions appeared when scientists exposed mice to an atmosphere enriched with either positive or negative ions (density: 52000 each of positive or negative charge carriers/cm3 air); after the exposure times of 5, 30 min and 1, 3, 10 d, the norepinephrine content of the brain was determined. While negative ions had no negative effect on the mice, positive ions caused elevations in norepinephrine levels within one day. When exposure to positive ions was continued for longer periods, ranging from 3 to 10 days, norepinephrine levels dropped. Results showed that positive ions cause stress after short time application in excess. After longer exposure, a state of exhaustion can be observed in the form of a lowered norepinephrine level.

Dowdall and Montigny (1985) conducted a study to know the effect of long-term exposure to positive or negative atmospheric ions on the responsiveness of rat forebrain neurons to serotonin (5-HT). 63 male Sprague-Dawley rats were divided into 3 groups, one was exposed to positive, 2nd to negative ions (1.5 × 10⁶ ions/ml) for 21 days, and a third group of rats served as controls. Unitary extracellular recordings from pyramidal neurons of the CA1 and CA3 regions of the dorsal hippocampus were obtained under urethane anesthesia, and their responsiveness to microiontophoretically applied acetylcholine (ACh), norepinephrine (NE) and 5-HT was assessed. One way and two way ANOVA was used to determine statistical significance. Results indicated that spontaneous rate of discharge and sensitivity to NE and ACh of hippocampal neurons were not affected by exposure to atmospheric ions. Exposure to negative ions increased the responsiveness of these neurons to 5-HT while exposure to positive ions decreased it. During the winter, a circadian rhythm of responsiveness to 5-HT was observed in the control group, sensitivity being lowest in the morning and highest in the evening. Exposure to ions disrupted this circadian rhythm; in rats exposed to negative ions, responsiveness throughout the day was similar to that observed in the evening in the controls, whereas in rats exposed to positive ions, the circadian rhythm of responsiveness to 5-HT was inverted. Brain concentrations of 5-HT, tryptophan, and 5-hydroxyindoleacetic acid were unchanged by exposure to atmospheric ions.
German researchers Goldstein and Arshavskaya (1997) conducted a study on animals and discovered a link between catecholamine regulation and lifespan after depriving experimental animals of negative ions. First, researchers isolated mice and rats in air-tight, sealed acrylic cases. Then, they filtered the ambient air to remove all negative ions from the sealed cases. Results were analysed by Wilcoxon and Mann-Whitney U-Test. Their research led to the discovery that a prolonged deficiency of negative ions led to an accelerated rate of death for the experimental animals. After examine the animals, Goldstein and Arshavskaya concluded that animal death is related to disturbances in neurohormonal regulation and pituitary insufficiency.

Nakane, Asami, Yamada, Ohira (2002) conducted a crossover study among 12 female undergraduates between an age range of 18–22, to examine the effect of negative air ionization on anxiety and salivary chromogranin A-like immunoreactivity (CgA-like IR), a protein indicator of sympathetic nerve activity. A biochemical index of the activity of the sympathetic/adrenomedullary system (i.e. salivary chromogranin A-like immunoreactivity (CgA-like IR)) and a self-report questionnaire (State-Trait Anxiety Inventory, Anxiety State--STAI-S) was used. Twelve female students carried out a word processing task for 40 min. The salivary CgA-like IR increased more than three times on the task, but the salivary cortisol did not change. The increase in the CgA-like IR level was attenuated by the exposure to negative air ions during the task. The exposure to the ions during the recovery period following the task was effective for rapidly decreasing the CgA-like IR level that had increased after the task. These effects by negative air ions were also observed using STAI-S. Task performance was slightly but significantly improved by the presence of negative air ions. The findings showed that exposure to negative air ions significantly reduced anxiety while performing a computer-oriented task, but negative air ionization in the post-task period was associated with a non-significant reduction. These results suggest that negative air ions are effective for the reduction of and the prompt recovery from stress caused by computer operation. Similar results were reported for CgA-like IR.

Fisher, Meltzer, Ziolko, Price, Moses-Kolko, Berga, Hariri (2006) examined the contribution of 5-HT1A autoreceptors to amygdala reactivity in 20 healthy adult volunteers and found a significant inverse relationship wherein 5-HT1A autoreceptor density predicted a notable 30-44% of the variability in amygdala reactivity. Researchers suggested a potential molecular mechanism by which a reduced capacity for negative feedback regulation of 5-HT release is associated with increased amygdala reactivity.
Studies reported above clearly shows the beneficial effects of negative air ions on regulation of chemical levels and reactivity. Research supports the view that negative ions have a net positive effect on health, including improved stabilized catecholamine regulation and enhanced recovery from physical exertion etc. Now, the following section is based on the analyses of respiratory problems and their potential relationships with air ions.

Herrington (1935) exposed 11 healthy male volunteers aged 18 to 25 years (6 subjects in the morning group and 5 subjects in the afternoon group) to positive and negative air ions to examine the effects on subjects’ respiratory rate. One hundred and fifty-nine experiments each extending over a period of 3 ½ hours were conducted. Fifty three of these were experiments in which positive ions were administered during a 30-minute period preceded and followed by similar control periods. In each of the 3 periods the physiological measurements were repeated. In 53 experiments this routine was repeated with negative ions. In a third series 53 control experiments were made in which the middle or "ionized" air period did not contain ions. Throughout the entire series the apparatus employed for the generation of ionized particles operated as usual with the single exception that ions either were or were not added to the air stream. Ion counts made in the breathing zone showed a concentration of 5 to 6x10^6 ions/cm^3. After 30 minutes ionization the concentration of ions in the middle of the room was about .5x10^6 ions/cm^3. When ion generators were turned off this concentration fell within 15 minutes to .1x10^6 ions/cm^3. After 30 minutes the count had a usual value of .04 to .07x10^6 ions/cm^3. Results revealed that no study participant exhibited significant changes in their metabolic rate, blood pressure, pulse rate, respiration rate, oral temperature and urine volume attributed to air ion exposure.

Kornblueh and Griffin (1955) measured the efficacy of negative air ion treatment among an adult and child patient population (n = 27) who suffered from respiratory symptoms. The majority of patients were previously diagnosed with hay fever, while a few were diagnosed with asthma or variants of rhinitis. Temperature and humidity in the experimental chamber were more constant than outside. The authors indicated that the majority of subjects reported complete or partial relief for hay fever symptoms, but there was no appreciable effect for patients with asthma or rhinitis.

In a subsequent publication by Kornblueh, Piersol, and Speicher (1958), the effects of positive and negative air ions on hay fever symptoms were evaluated among 123 children and adults aged between 4 and 59. The exposures to negative ionization were made at
concentrations ranging from 1200-2600 ions/cc. Higher figures from 2000-6500 ions/cc were obtained with the positive polarity. The duration of exposures varied from 12 to 50 minutes. During controlled conditions the ionization level was 200-600 ions/cc. 74 patients had pollinosis. Out of 54 individuals treated with negative ionization 34 received partial to complete relief where as only one of 15, exposed to controlled conditions showed improvement. Positive ionization gave no relief. For 49 patients with hay fever results indicated that exposure to negative air ions was associated with hay fever symptom relief among symptomatic subjects, but did not result in symptoms among asymptomatic subjects. Positive air ion exposure did not result in symptom alleviation, but was associated with the development of symptoms in asymptomatic subjects. Of note, the sample size of the positive air ion group was considerably smaller than the negative air ion group. Statistical testing was not performed.

Zylberberg and Loveless (1960) conducted a double-blind, controlled study on 15 asthmatic men and women (aged 15–53) during two 120-minute exposure periods to ionized air of concealed polarity, followed by a repeat experiment with the opposite charge. No differences in the biologic effect of positive or negative air ions were observed, although dryness of the nose or throat was reported for both ion polarities. The negative (like the positive) ions did not appear to influence the patient's typical pattern of wheezing and of remission. Dryness of the nose or throat was also a frequent side effect, regardless of charge. They reported wheezing in symptom-free asthmatic subjects seemed to occur with negative ionization of the air in some instances. No amelioration of this symptom once present was noticed when subjects were similarly exposed.

Lefcoe (1963) evaluated the impact of positive and negative air ion exposure among 24 adults with mild obstructive pulmonary disease (15 mild to moderate asthma patients, 5 mild bronchitis patients, and 4 patients with a history of hay fever) consisted of forced vital capacity (FVC), FEV₁, and maximum mid-expiratory flow rate (MMFR) measurements. The patient was exposed to positive, negative or no ionization. The patients were retested after the exposure. The level of the ions were 125000 ions/cc. The measurements were taken hourly, for four hours pre exposure and four hours observations post treatment. No significant effects on respiratory function between exposure to positive, negative, and no ionization were reported.

Blumstein, Spiegelman, Kimbel (1964) conducted a double-blind randomized study to investigate the influence of positive and negative air ion treatment on allergic respiratory
conditions in 26 adults (12 hay fever cases, 10 asthma cases, and 4 pulmonary emphysema cases). Each individual has a complete history, physical examination and was subjected to a battery of six pulmonary function tests before and after each treatment course. Each patient received successively five consecutive daily treatments of 30 minutes exposure to a concentration of 100,000 ions/cc of negative polarity, positive polarity and placebo therapy. Researchers found no significant changes in patients’ conditions when subjectively or objectively assessed by vital capacity, timed vital capacity (TVC1 and TVC3), MBC, the maximum expiratory flow rate, and the single breath test.

Motley and Yanda (1966) conducted multiple experimental, non-randomized studies among different adult populations to examine the influence of negative and positive air ions on pulmonary function as determined by TVC, Forced Expiratory volume (FEV), MBC, and mean peak flow rates. Ion densities of approximately 5,00,000 ions/ml at the level of the nose of the subject. In one study of 46 adults with severe emphysema or fibrosis, or both, 13 patients were exposed to negative air ions for 1 hour and 33 patients were exposed to negative air ions for 3 hours, and no significant effect on lung volume measurements were observed. Similarly, the authors reported no significant effect of negative air ion exposure (7 to 12 hours daily for 2 weeks) on lung volume measurements in 19 patients with severe pulmonary emphysema; no significant differences between these 19 patients and 7 unexposed control subjects; and no significant alterations in blood gas exchange measurements (after exposure to negative and positive air ions) or chronic pulmonary disease in 44 and 35 cases, respectively.

Palti, De Nour, and Abrahamov (1966) performed 41 experiments and examined the effects of air ion exposure among 13 infants diagnosed with bronchial asthma and 6 comparison infants free of respiratory symptoms. The authors summarized that negative air ion exposure resulted in reduced respiratory spastic attacks while positive air ion exposure increased spastic attacks in normal infants. On the average, the effects of these ions on respiratory spasticity becomes evident about 10 hours after the beginning of ionization. However, statistical significance testing was not performed to estimate the reliability of the reported effects.

Stark, (1971) conducted a study in a Swiss textile mill, to study the effect of negative ions respiratory related illnesses. Negative ionizers were placed in two, 60’ by 60’ rooms, each containing 22 employees. In one room, the negative ion electronic air cleaner was turned on during the course of the study. In the other room, the negative ion air purifier was
permanently turned off, although the employees in this room were led to believe they were working in a room enriched by negative ions. During this six-month study, a total of 22 sick days were lost by employees working in the room in which the negative ionizer was operating. In the room where the machine was not operating, a total of 64 days were lost to sickness. During a month-long flu epidemic, the first group lost a total of 3 days to sickness, while the second group lost a total of 40 days to sickness.

Jones, O’Connor, Collins, Watson (1976) performed an experiment during a 16-week period to determine the efficacy of negative air ion treatment for bronchial asthma in seven patients (six males and one female) aged 10 to 54 years. Their progress was followed using objective tests of lung function and clinical assessment. Monthly measurements of lung function included FEV₁, peak expiratory flow rate (PEFR), forced mid-expiratory flow, forced vital capacity (FVC), and static lung volumes. After analysing the results by Mann-Whitney U-test authors observed that four subjects experienced a significant increase in morning PEFR during the exposure period, but this effect was no longer present in two of these subjects during the subsequent non-air-ion exposure period. In a two-way group analysis, however, they reported that the patients as a whole showed no statistically significant differences between the placebo, treatment, and no treatment periods.

Osterballe, Weeke, Albrechtsen (1979) studied the influence of artificially generated atmospheric ions in 15 patients with bronchial asthma. Seven women and eight men aged between 16 and 48 years and with duration of asthma from 2-43 years were tested. The patients were divided into two groups. Group 1 comprised of 10 patients with reversible obstructive lung disease and decreased lung function without medicine and second group comprised of 6 patients including one from the exposure trial. All patients have bronchial hypersensitivity to histamine. As high concentration a value of approximately 30,000 ions/cm³ was used for positive as well as for negative ions. In case of controlled conditions the concentrations of positive and negative ions were about 50 ions/cm³. Results indicated a slight but significant (at 5% level) improvement in the lung function was demonstrated in nine patients during positive as well as negative ion exposure, but the patients’ subjective votings of the air quality did not show any changes due to ion exposure. No change in the histamine threshold of the airways in six patients with bronchial asthma was demonstrated during exposure to ions.
Ben Dov, Amirav, Shochina, Amitai, Bar-Yishay, and Godfrey (1983) evaluated the effect of negative ionization on bronchial reactivity among seventeen asthmatic patients, 11 boys and six girls. The experiment was double-blind and the 11 asthmatic children were challenged twice by exercise and 10 were challenged twice by histamine inhalation. The ion concentration measured at the mouthpiece for each individual was constant and ranged from $5 \times 10^5$ to $10 \times 10^5$ ions/cm$^3$ during the exercise tests and from $4 \times 10^5$ to $5 \times 10^5$ ions/cm$^3$ during the histamine challenge tests. The children breathed negatively ionised air or control room air in random order. All challenges were matched in terms of basal lung function and the exercise tests were matched in terms of ventilation and respiratory heat loss. Results were analysed by t-test. Exercise induced bronchial reactivity was reduced in all but one study subject, at concentrations of air ions in the mouthpiece approximately 100 to 1,000 times greater than typical background levels. No appreciable effects on resting lung function were observed, and the effect of ionized air on the sensitivity of inhaled histamine was equivocal. Five of the 10 subjects were less sensitive to histamine and the other five more sensitive when breathing ionised air. It was concluded that negative ionisation of inspired air can modulate the bronchial response to exercise but the effect on the response to histamine is much more variable.

Dantzler, Martin, and Nelson (1983) examined the effect of moderately extended positive and negative air ion exposure in nine adult patients, 8 females and one male (age range: 35–64 years) with bronchial asthma in a double-blind controlled study, of whom seven had reported increased respiratory symptoms in association with weather changes. On consecutive days, while grounded, patients were exposed for six hours to approximately 100,000/cc of either positive or negative ions. Pulmonary function, pulse and blood pressure were measured throughout the exposure. Questionnaires to assess emotional state and physical symptoms were completed after 15 minutes and five hours each day. Urinary 5-hydroxy indoleacetic acid (5HIAA) excretion was measured. Patients were continued on theophylline but adrenergics and corticosteroids were withheld. Results were analysed by t-test and chi-square and indicated that no patient experienced an exacerbation of asthma. Symptoms, pulmonary function, pulse and blood pressure, urinary 5HIAA excretion and the response to the questionnaires did not differ significantly between the two ion exposures. Thus moderately long exposure to positive or negative small air ions did not influence the clinical condition of these patients, many of whom reported exacerbations with weather changes. The findings do
not support a significant role of small air ions in exacerbations or treatment of bronchial asthma.

Nogrady and Furnass (1983) evaluated 19 adults (10 men and 9 women, mean age 36 years) with stable asthma over six months, in a double-blind crossover study to examine the impact of negative air ion exposure on bronchial asthma. After an initial two week period without an ioniser, active or placebo ionisers were installed in subjects' bedrooms for two week periods separated by a four week "washout" period when no ioniser was present. The study was completed by a final four week period when no ioniser was present. Subjects were randomly allocated to receive an active or a placebo ioniser first. Subjects recorded their peak expiratory flow rate (PEFR) twice daily, completed a daily symptom score questionnaire, and noted any treatment they took on a diary card. Recordings were completed throughout the trial. Ion counts and dust concentrations were measured in subjects' bedrooms during the study. Ion counts were maintained above 150 000/ml at the level of the subject's pillow. Mean ion counts rose considerably when ionisers were activated (p less than 0.001). In their 6-month study, the authors found no statistically significant differences in PEFR, symptom score, or consumption of medication between the periods that active ionisers and either no ionisers or placebo ionisers were in operation. This study has failed to show a statistically significant benefit in asthmatic subjects from the use of negative ion generators.

Wagner, Danziger, and Nelson (1983) conducted an experimental study to investigate the association between positive or negative air ions, random variations in meteorological factors (ambient temperature, barometric pressure, wind velocity, precipitation, and air pollution), and mean peak flow rates in twelve patients who were selected on the basis of a history of weather-induced worsening of asthma. Among those 12, six were male and six were female patients (age range: 41–69 years, mean age 54 years) with moderate to severe asthma. Peak positive and negative small air ions counts ranged from fewer than 500 to slightly more than 1600 ions/cc. Patients measured pulmonary functions four times daily at the same time when measurements of small air ions and other meteorological parameters were obtained. Results were analysed by t-test and found that mean peak flow rates did not differ significantly with alterations in air ion levels or other meteorological parameters linked to the occurrence of two weather fronts during the study.
Lipin, Gur, Amitai, and Godfrey (1984) measured respiratory effects of positive air ions on 12 asthmatic children under physical exertion, seven of them were boys, with a mean age of 12 (range 9-15) years. The child refrained from taking sympathomimetic medication or sodium cromoglycate for at least 12 hours and long acting theophylline for 24 hours before any test. Exercise tests were undertaken with and without exposure to positively charged inspired air using a randomized, double-blind design. The subjects breathed cold, dry air with or without the addition of positively charged ions for 10 minutes before exercise and throughout the exercise and subsequent recovery. Ion concentration for each individual was (5-10 $\times 10^5$ ions/cm$^3$) during the exercise tests. All challenges were matched in terms of basal lung function and exercise tests were matched in terms of ventilation and respiratory heat loss. Results were analysed by using t-test and authors reported that the post-exercise fall in forced expiratory volume ($\text{FEV}_1$) was significantly greater ($p = 0.04$) during exposure to positive air ions compared with the control group, but no significant effects were observed for other comparisons (e.g., ventilation, oxygen consumption).

In another study of asthmatic boys ages 8 to 12 (n = 24), Kirkham, Hawkins, Guyatt, Lumley, Horsfield, and Cumming (1984) analyzed the effects of negative air ionizers on lung mechanics. They found no significant differences in initial or post-study period lung function values between the groups.

Warner, Marchant, and Warner (1993) evaluated the effect of ionizers on airborne concentrations of house dust mite allergen Der $p$ I in a double-blind, crossover, placebo controlled trial. The study was carried out in the homes of 20 children with allergic asthma of median age 9 (range 3-11) years were selected. Subjects recorded their peak expiratory flow rate (PEFR) twice daily and completed a daily symptom score and treatment schedule on a diary card for two six week periods, one with an active ioniser and the other with a placed ioniser (randomly allocated) used in the living room and the bedroom. The authors found that although there was a significant decrease in airborne Der $p$ I concentrations, no significant changes were observed for PEFR, symptom scores, or treatment usage. Wilcoxon signed rank sum test for the clinical observations, and the X2 and Mann-Whitney U tests for the allergen measurements were used as statistical analysis. The authors observed a trend in increased night time cough during the active ionizer period, but the association did not reach formal statistical significance.
A wide range of respiratory measures, including respiratory rate, multiple measures of pulmonary function, and other physiological measures collectively have been reviewed above. Studied quoted above did not provide much evidence of positive effect of negative air ions exposure on respiratory measures. Although a few of them have shown significant effect but some of them are showing contradictory results as well. The following section is related to the literature available on effects of air ions on various psychological correlates such as anxiety, depression, mood, stress, reaction time etc. Following section reviewed the studies related to negative air ions and its relationship with anxiety.

Deleanu and Stamatiu (1985) conducted an experiment on 112 patients with mental disorders. On the basis of the psychiatric diagnoses the 112 patients were divided into 3 groups on the basis of psychotic problems. The overall study goal was to mitigate patients’ symptoms by exposing them to negative aeroionotherapy for 10 to 30 days. The airoionotherapy cure consisted of one sitting daily, for 10-30 days. First sitting lasted 15 minutes, then the duration of exposure was individualised depending on the evolution of target symptom Corona and water air ion generators, as well as electro-aerosol generators, were used. The aeroionization (small air ion concentration), at the patient's respiration level, was moderate: n=10,000 – 15,000/ml air; n½=1,000/ml air; q=n½/n0. Results indicated that in most treated patients a diminution or even the disappearance of the target symptoms was obtained. Those obviously ameliorated under the influence of aeroionotherapy were: asthenia, depressive reactions, anxiety, cephalea, insomnia, and general indisposition. These findings suggested that in the majority of treated patients, attenuation or the complete disappearance of anxiety and depressive reactions, including insomnia and general disposition, were identified.

Gianinni, Jones, and Loiselle (1986) used a double-blind crossover design to evaluate the influence of negative and positive air ions. The study was conducted on 14 university-affiliated volunteers. Earlier, Clinical reports and animal studies support the existence of a "serotonin irritation syndrome." Volunteers were exposed to generated ambient cations and anions under controlled conditions. Results indicated that positive air ionization significantly increased anxiety, excitement, and suspicion. In contrast, negative air ionization significantly lowered subjects’ extent of suspicion and excitement to those levels attained prior to positive air ion exposure.
Gianinni, Jones, Loiselle, Price (1986-1987) researched the effects of positive air ions only in a double-blind crossover study conducted among 12 adult male volunteers. Volunteers were exposed to a highly cationized environment for two hours. Serotonin level and 24 hour 5-HIAA urine levels were also measured at different points. A Brief Psychiatric Rating Scale was used to evaluate behavioural response. The cation concentration during the experiment ranged from 2050-2300 cations/cm³. Results were analysed by Mann Whitney U test and found that anxiety, excitement, and serum serotonin levels significantly increased when exposed to positive ions.

Misiaszek, Gray, Yates (1987) conducted a study to investigate the effects of negative air ion exposure on a specific subgroups of psychiatric patients. They explored the influence of negative air ions on eight manic patients (3 males and five females). The subjects falling between an age range of 22–49, were selected in an experimental pilot study conducted in two phases of four subjects each. The first phase was non-blind and the second was double-blind involving collection of data using anxiety and psychiatric metrics. In first phase, four subjects were exposed for 1 hour to 40,000-60000 small, 50-1000 medium and 50-4000 large negative air ions per cubic centimetre. In second phase, double blind three hour study session, each subject received in random order an actual ion treatment of 50,000-70,000 small, 50-3200 medium and 50-7000 large negative air ions per cubic centimetre and a simulated treatment. Each ion or simulated treatment was 1.5 hour long and the subjects were observed throughout 3 hour session. Before and after each treatment, subject also completed a self evaluation questionnaire. Results revealed that three of the four subjects showed score reductions consistent with clinical improvement; however, inference of these findings was impossible due to the limited number of subjects examined.

Gianinni, Giannini, Melemis, Giannini (2007) conducted a double-blind crossover experiment in which they exposed 20 acutely manic men between an age range of 23–29 having mean age 26.7, to high levels of ambient negative air ions. Anions were produced by an anion generator in a sealed room. Responses were evaluated with the Brief Psychiatric Rating Scale by 2 blinded raters. All this produced a significant antimanic effect: total rating scores declined with anion treatment and thus, results indicated a statistically significant reduction in subjects’ manic states.
In contrast, Malcolm, Cowen, Harmer (2009) conducted a single-blind experiment among 30 healthy subjects (17 females and 13 males) between an age range of 18–28, randomized to receive either high-density negative air ions or a control condition. Results revealed no effect of exposure on anxiety as well as on subjects’ feelings of alertness or calmness.

These experimental researches indicate that exposure to negative ions is linked to less anxiety. Various studies examined the effects of negative and positive air ions on depression which are covered in the following section.

Terman and Terman (1995) performed a study to evaluate the antidepressant effect of negative ions in the ambient air as a potential treatment modality for seasonal affective disorder. Twenty-five subjects, having 22 women and 3 men (mean age: 38.2) with winter depression underwent a double-blind controlled trial of negative ions. Subjects were randomized to low-density ($1 \times 10^4$ ions/cm$^3$, $n=13$) or high-density ($2.7 \times 10^6$ ions/cm$^3$, $n=12$) treatment using an electronic negative ion generator with wire corona emitters. Home treatments were taken in the early morning for 30 min over 20 days, followed by withdrawals. Two way repeated measure ANOVA was used as statistical analyses. The authors found that depression severity decreased (determined using SIGH-SAD) more notably for the high- than the low-density treatment group. Applying a remission criterion of $\geq 50\%$ reduction in symptom severity, 58\% of patients reacted to high-density and 15\% reacted to low-density air ion exposure. There were no side effects attributable to the treatment, and all subjects who responded showed subsequent relapse during withdrawal. Treatment with a high-density negative ionizer appears to act as a specific antidepressant for patients with seasonal affective disorder. They suggested that this method can be useful as an alternative or supplement to light therapy and medications.

Terman, Terman, and Ross (1998) conducted a double-blind crossover experiment to examine the effects of timed bright light and negative air ionization on sleep timings and winter depression. This study used a morning×evening light crossover design balanced by parallel-group controls, in addition to a nonphotic control, negative air ionization. The study was conducted on 158 Subjects with seasonal affective disorder falling between an age range of 18–59 with mean age: 39.4, were randomly assigned to 6 groups for 2 consecutive treatment periods, each 10 to 14 days. Light treatment sequences were morning-evening, evening-morning, morning-morning, and evening-evening (10000 lux, 30 min/d). Ion density
was 2.7×10^6 (high) or 1.0×10^4 (low) ions per cubic centimeter (high-high and low-low sequences, 30 min/d in the morning). The findings showed that exposure to high-density versus low-density negative air ionization did not result in statistically significant differences in sleep patterns. But for depression they showed that exposure to high-density air ionization provided subjects with clinically significant relief by producing a 50% reduction in depressive symptoms. In addition, the remission rate associated with high-density negative air ionization rose substantially with an additional 10 to 14 days of treatment after the first period, but low-density exposure showed no significant effect. Light therapy acted as a specific antidepressant in SAD, and morning treatment was most effective. High-density negative air ionization also appears to have a specific antidepressant effect.

Goel, Terman, Terman, Macchi, and Stewart (2005) conducted a double-blind randomized controlled trial to evaluate the efficacy of two non-pharmacologic treatment, a bright light and high-density negative air ionization for non-seasonal chronic depression and sleep in 32 patients of which 24 were women and 8 were men, ages 22-65 years with mean age 43. Patients were entered throughout the year and randomly assigned to exposure to bright light, (10 000 lux, n=10), or high-density (4.5×10^{14} ions/s flow rate, n=12) or low-density (1.7×10^{11} ions/s, n=10, placebo control) negative air ions. Home treatment sessions occurred for 1 hour upon awakening for 5 weeks. Blinded raters assessed symptom severity weekly with the Structured Interview Guide for the Hamilton Depression Rating Scale--Seasonal Affective Disorder (SIGH-SAD) version and evening saliva samples were also obtained before and after treatment for ascertainment of circadian melatonin rhythm phase. For analysing the data repeated measure Two way ANOVA was used. Results indicated that SIGH-SAD score improvement was 53.7% for bright light and 51.1% for high-density ions v. 17 and 0% for low-density ions. Remission rates were 50%, 50% and 0% respectively. The presence or severity of atypical symptoms did not predict response to either treatment modality, nor were phase advances to light associated with positive response. Both bright light and negative air ions are effective for treatment of chronic depression. Remission rates are similar to those for SAD, but without a seasonal dependency or apparent mediation by circadian rhythm phase shifts. In other words, the findings showed no significant change in sleep onset between high-density (n=12) and low-density (n=10) negative air ionization; but a significant alteration in sleep offset was noted among the high-density subjects.
Terman and Terman (2006) assessed two novel non pharmaceutical treatments for winter depression—naturalistic dawn simulation and high-density negative air ionization—delivered during the final hours of sleep. They conducted a double-blind RCT on 99 adults patients having 77 women and 22 men, (age range: 19–63; mean age: 40.4) with the winter seasonal pattern of major depressive disorder (94 cases) and bipolar II disorder (five cases). Five parallel groups received 1) dawn simulation (0.0003–250 lux in the pattern of May 5 at 45° north latitude); 2) a dawn light pulse (13 minutes, 250 lux, with an illuminant dose of $3.25 \times 10^7$ lux-minutes matched to the simulated dawn); 3) post awakening bright light (30 minutes, 10,000 lux); 4) negative air ionization at high flow rate (93 minutes, $4.5 \times 10^{14}$ ions/second); or 5) ionization at low flow rate (93 minutes, $1.7 \times 10^{11}$ ions/second). The symptoms were assessed over 3 weeks with the Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorder Version. Results indicated that after post treatment improvement were bright light, 57.1%; dawn simulation, 49.5%; dawn pulse, 42.7%; high-density ions, 47.9%; and low-density ions, 22.7% (significantly lower than the others). Contrary to the authors' hypothesis, analysis of variance failed to find superiority of dawn simulation to the dawn pulse or bright light. However, the dawn pulse led to a pattern of residual or exacerbated depressive symptoms similar to those seen in low-density ion non responders. Naturalistic dawn simulation and high-density ionization are active antidepressants that do not require the effort of post awakening bright light therapy.

Flory, Ametepe, and Bowers (2008), conducted a study over the course of 5 years, and assessed the antidepressant efficacy of two active treatments, bright white light and high-density negative ions, and the efficacy of two placebo treatments, dim red light and low-density negative ions, for Seasonal Affective Disorder (SAD) among 73 university-affiliated women The group included 67 White and 7 Black women, (age range: 18–51; mean age: 20.8) in a single-blind RCT. These women with SAD were exposed to one of the four treatment conditions over 12 consecutive days. Structured Interview Guide for the Hamilton Depression Rating Scale-Seasonal Affective Disorder Version-Self Rating (SIGH-SAD-SR) and Beck Depression Inventory (BDI) were used for assessment. At the subject's sitting position of ~60 cm from the generator, the ion output of the high density unit was $\geq 2.0 \times 10^6$ ions/cm$^3$, while that of the low-density unit was $\sim 4.0 \times 10^3$ ions/cm$^3$. Correlation and chi-square was used as statistical analysis. Results indicated that over the course of treatment, the scores of all the subjects in all four groups decrease significantly. For raw scale scores,
neither main effects of treatment nor interactions between treatment and time were significant. When remission outcome criteria were used, bright white light was significantly more effective than any of the other three treatments, and exposure to high-density negative ions was more effective than either of the two placebo conditions, although the difference was not significant.

Of note, the clinic that performed the Malcolm, Cowen, Harmer (2009) study subsequently, another study was performed by Harmer, Charles, McTavish, Favron, and Cowen (2012) to investigate whether a single session of High-density negative ion (HDNI) treatment could reverse negative affective biases seen in seasonal depression or not. They conducted a double-blind, placebo-controlled randomized study with 21 adult patients with SAD and 21 control, exposed to high-density negative air ions, and also used a battery of emotional processing tasks. Results were analysed by two way ANOVA and indicated that under placebo conditions, participants with seasonal mood disturbance showed reduced recognition of happy facial expressions, increased recognition memory for negative personality characteristics and increased vigilance to masked presentation of negative words in a dot-probe task compared to matched healthy controls. Negative ion treatment increased the recognition of positive compared to negative facial expression and improved vigilance to unmasked stimuli across participants with seasonal depression and healthy controls. Negative ion treatment also improved recognition memory for positive information in the SAD group alone and also reported no effect on measures of visual analogue (mood) or State-Trait Anxiety Inventory ratings.

Dauphinais, Rosenthal, Terman, DiFebo, and Tuggle (2012) performed a double-blind RCT of 44 adult patients with bipolar depression to examine the effect of negative air ions. Subjects were randomized to low-density (n=20), high density (n=2), or bright light (n=18) treatment for 8 weeks. Of note, the low-density group was considered the control and too few data were available for the high-density group to allow for a meaningful analysis; therefore, data among the high-density group were not reported. The primary measure of efficacy was the Structured Interview Guide for the Hamilton Depression Rating Scale with Atypical Depression Supplement (SIGH-ADS). Adverse events were assessed using the Young Mania Rating Scale (YMRS) and Systematic Assessment for Treatment Emergent effects (SAFTEE). All outcome variables were statistically analyzed using a mixed model repeated measure analysis of variance (ANOVA). The authors found no significant difference between
the depression severity scores (determined using SIGH-SAD) of the light and low-density treatment groups (52% vs. 47% reduction, respectively) or between the proportion of responders and remitters (light group—50% of subjects were either responders or remitters; low density ion group—55.6% of subjects in the low-density treatment group were either responders or remitters).

All depression studies evaluated potential alterations only from exposure to negative air ions. Negative air ionization and depression suggested a decreased severity of symptom scores in subjects with exposures to high air ion levels. Specifically, a decrease in depression scores, corresponds to an improvement in subjects’ depressive state. Many other studies studied its impact on mood which is reviewed in the following section.

Early experiment on air ions effect on complex mental task, vigilance, and mood, was conducted by Chiles, Cleveland, and Fox (1960) on human-beings. They used repeated measure design with single blind counter balancing. Experiment was done with both types of polarities i.e. positive and negative. Air was delivered through an electrostatic precipitator system. Doses of negative air ions and positive ions were 2.6 x10^4 ion/cm^3. Subjects were exposed for two hours. No significant effect on performance and mood were found.

Tom, Poole, Galla, and Berrier (1981) utilized a double-blind randomized controlled study to determine the impact of negative air ions on mood in 56 adults (44 female and 12 male) between an age range of 17–61 with mean age 23. They measured reaction times, rotary pursuit and mood in the presence of negative air ions. Subjects were tested either in a normal-ion environment (control group) or in a predominantly negative ion environment (experimental group). An exposure of negative air ions was given for 15 minutes with a dose level of 1.6x10^4 ions/cm^3. After a 15-minute acclimation period, subjects asserted their psychological state and completed 2 performance tasks. Results indicated that subjects had faster reaction times and reported feeling significantly more energetic whereas no effect on rotary pursuit was observed under negative-air-ion conditions than under normal-air conditions.

On the other hand, Buckalew and Rizzuto (1982) conducted a double-blind randomized controlled trial (RCT) study. This study investigated specific subjective or psychological effects of relatively long exposure to negative ions generated by a conventional air
purification device. The study was conducted on 24 males which were equally divided into two groups. One was experimental (n=12 men) and other was control group (n=12 men) between an age range of 20–30 having mean age 22.8. Subjects were matched for age, education, physical condition, and smoking habits. Control group was confined to the test chamber for a 6 hour period under air ion conditions typical of an energy efficient building. The second group was similarly confined, but ion generators began operating 2 hours before occupancy and continued for all 6 hours of confinement. Generators were masked for all indications of operation, and were also present under control conditions but not turned on. The groups were subjected to normal and negatively charged atmospheres, respectively. The tests used were the Taylor Manifest Anxiety Scale (TMAS) and a self-report mood index. The analysis of TMAS change scores clearly showed no effect of negative ion exposure on anxiety. Analysis of mood index data showed significant changes in the subjective perception of both physiological state (relaxation increased) and psychological state (irritability, depression, and tenseness decreased while calmness and stimulation increased) for experimental group.

Baron, Russell, and Arms (1985) examined the effect of negative air ionization on mood, memory, and aggression as mediated by personality type. The study was conducted on 71 male undergraduate students in a single-blind experiment. Individuals scoring high (Type As), intermediate, or low (Type Bs) on the Jenkins Activity Survey were given an opportunity to aggress against a stranger who, previously, had either provoked or not provoked them. The opportunity to aggress took place in the presence of (a) a high concentration, (b) a moderate concentration, or (c) a low (ambient) concentration of negative air ions. Results indicated that exposure to moderate or high levels of negative ions significantly enhanced aggression by Type A subjects, but not by other participants. In addition, it was found that negative ions produced positive shifts in subjects' reported moods in the absence of provocation, but negative shifts in moods in the presence of provocation. These findings suggest that moderate or high concentrations of negative ions serve as a source of heightened activation, thus enhancing individuals' dominant reactions or tendencies in a given situation.

Goel and Etwaroo (2006) performed a single-blind RCT to determine the immediate effects of bright light, auditory stimulus, and high-density (n=29) and low-density negative air ionization (n=30) on mood and attentiveness. This study compared the short-term effects of
bright light, an auditory stimulus, and high- and low-density negative ions on mood and alertness in mildly depressed and non-depressed adults. The study was conducted on 118 subjects, 69 women and 49 men (mean age+/−S.D., 19.4+/−1.7 years), participated once across the year. Subjects were randomly assigned to one of four conditions: bright light (10,000 lux; n=29), auditory stimuli (60 dB; n=30), or high-density (4.5x10(14) ions/s flow rate; n=29) or low-density (1.7x10(11) ions/s; n=30; placebo control) negative ions. Exposure was for 30 min on three consecutive evenings between 1900 and 2100 hours. Mood and alertness assessments, using standardized scales, occurred before, and 15 and 30 min during exposure. The Beck Depression Inventory classified subjects as depressed (> or =10; n=35) or non-depressed (<10; n=83). The results showed that exposure to high-density negative air ionization decreased depressive symptoms, total mood disturbance, or anger within 15 to 30 minutes of exposure; however, low-density exposure did not produce significant effects. The auditory stimulus, bright light and high-density ions all produced rapid mood changes – with small to medium effect sizes – in depressed and non-depressed subjects, compared with the low-density placebo, despite equivalent pre-study expectations. Thus, these stimuli improve mood acutely in a student sample, including a subset with depressive symptoms.

Studies reviewed above have shown a significant effect of negative air ion exposure on mood states of subjects. Several studies examined the impact of negative and positive air ionization on stress.

A field experiment was conducted by Hedge and Collis (1987) in which they examined the impact of negative air ionization on self reported stress and arousal on the performance of a colour naming task and the Stroop Colour Word test, and mood in a double-blind study conducted among 28 healthy women. The females were hospital secretaries aged between 19 to 58 years with a mean age of 42 years. The negative air ion concentration in the ionization condition was 2.0 x 10^4 ions cc^{-1} while that for the placebo condition was 2.5 x 10^2 ions cc^{-1}. Each subject completed three sessions in each of the three main conditions (control, placebo and negative air ionization). The order of condition was randomized for each subject. Results were analysed by repeated measure analysis of variance using MANOVA. No significant effects of negative ions on cognitive task performance or on self rated stress and arousal could be demonstrated, in this study.
Livanova., Levshina., Nozdracheva., Elbakidze, and Airapetians (1998) at the Russian Academy of Sciences in Moscow after conducting a study on rats discovered that negative ions are able to help protect the body from induced physical stress. When the researchers immobilized rats and exposed them to negatively charged air ions they discovered that the ions prevented the development of pathological changes characteristic of acute stress that are observed in untreated rats. The protective action of negative air ions was observed in all the experimental animals independently of their types of behavior.

On the other hand, Iwama, Ohmizo, and Obara (2004) conducted a study to measure the relaxing effect of negative air ions on ambulatory surgery patients. It was a double-blind experiment with 95 patients: 44 patients randomized to the control and 51 patients randomized to receive negative air ion treatment (mean age: 40). Negative ions were generated by means of water shearing and was operated in the operating room (OR; 30 m³). An ion detector showed approximately 1000 parts/mL of negative ions and zero parts/mL of positive ions. In the regular OR environment, it showed a level of zero for both ions. The temperature and humidity of the room were measured by a digital thermohygrometer. Patients received no premedication and fluid infusion, and were asked by blinded nursing personnel to grade their degree of tension as: 1 = relaxed; 2 = normal tension; 3 = mild tension; 4 = moderate tension; and 5 = severe tension, before entering the OR. After leaving the OR, the same nurse asked the degree of tension during the first or latter half of the surgery. There was no statistical difference between groups with regard to age (37 ± 18, 43 ± 20 yr), male/female ratio (17/27, 23/28), height (159 ± 16, 160 ± 9 cm), weight (59 ± 21, 57 ± 8 kg), room temperature (25.6 ± 1.4, 26.0 ± 1.3°C) and humidity (38.7 ± 9.2, 40.6 ± 12.0%), expressed as the mean ± SD or number. The degree of tension decreased significantly and more rapidly in the negative ion-rich environment. The results suggest that negative ions produced by water shearing have a relaxing effect in the OR environment.

Malik, Singh, Singh (2010) conducted a study to examine the effect of Negative Air Ions (NAI) exposure on physiological and psychological indicators of stress during a two-hour long computer-oriented task and induced stress in 20 adults between an age range of 24–35 with mean age 28.9 in a single-blind study. The stress was induced in three different conditions i.e. 'control condition, control condition-placebo effect and experimental condition. Results were analysed on the basis of pre-post testing. Heart beat was significantly different in third (therapeutic) condition (F = 6.0, p < 0.01). Moreover, not only in therapeutic setting significant changes in heart beat (t = 2.9, p < 0.01) were observed in pre (77.4 bpm)
and post-testing (72.1 bpm), Computer-oriented stress and psychological stresses were also significantly reduced in therapeutic condition (F = 3.6, p = <0.05). But, there was no significant difference between control and placebo control in all the three conditions. Thus, there was a significant decrease in computer-oriented stress and psychological stress following negative air ionization.

Some experimental researches reviewed above indicate that exposure to negative air ions is linked to reduction in stress and thus improving the performance. Following section would deal with the studies related to reaction time and performance and its potential relationship with negative air ions.

Slote (1961) did experiment on human subjects using both positive and negative air ions polarities. A dose level of 2.0x104ions/cm3 of both polarities was used. Reaction time and flicker fusion tasks were measured repeatedly. Exposure of ions was given for 15-25 minutes for both positive and negative air ions. Results showed an increase in reaction time with positive ion exposure and decrease with negative air ions exposure. Whereas opposite effects were found for clicker fusion task.

Knoll, Rheinstein, Highberg and Leonard (1961) did experiment to study the effects of ions on simple visual reaction time in human beings using a repeated measure design. A dose level of 2.0x103 to 1.0x106 ions /cm3 of both the polarities were used. Exposure of positive and negative air ions were given for one hour. Results showed a remarkable decrease in reaction time with negative air ions and increased reaction time with positive ion exposure.

Halcomb and Kirk (1965) measured reaction time using both polarities i.e. positive and negative air ions on human beings. An independent two group design was used. An exposure of both positive and negative air ions with a dose level of 1.0x104ions/cm3 was given for 4.3 hours. Reaction time increased with an exposure of positive ions and decreased with negative air ion exposure.

Wafford (1966) experimented with negative air ions. The problem was to determine the effects of increased negative ionization upon discrimination reaction time and manipulative dexterity tasks. 100 subjects from undergraduate psychology classes performed research tasks under an increased density of negative ions while 100 control subjects performed under normal conditions. A total of 66 males and 34 females were used in each group. 20 minutes exposure was given to the subjects of negative air ions. An independent two group design
was used and reaction time was measured. Increased negative ionization had a significant effect upon latency of reaction time but not upon measures of manipulative dexterity. Simple forms of behavior seem to be influenced more by negative ionization than the complex behavior.

Using independent three groups design McDonald, Bachman, and Lorenz (1967) did an experiment on air ions. For the experiment reaction time and vigilance task were used. Six independent groups of 14 male students were used. Mean ages of these groups ranged from 20.2 years to 26.9 years. An exposure of \( \sim 10^6 \text{ions/cm}^3 \) was given to the human subjects for 45 minutes. No impact of either polarity was found on reaction time. But vigilance increased with both positive and negative air ions. No effect on heart rate and electrical potential was observed but respiration rate decreases.

Hawkins and Barker (1978) measured human performance on motor tasks and reaction time. For this purpose 45 healthy male subjects having an age range 18-26 years were selected. They were randomly assigned to three independent groups: one group was tested in ‘natural’ ion environment, 2nd in a predominantly ‘negative ion (7.0x10^3 \text{ions/cm}^3)’ environment, and 3rd in a predominantly ‘positive ion (7.0x10^3 \text{ions/cm}^3)’ environment. Exposure of both the polarities was given for 2 hours. Fine control sensitivity, Reaction time and rate control were assessed. Results were analyzed by F-test showing significant increase in the performance on all the tasks with negative ion exposure. But no any negative effect of positive ions was found. Subject performed best in the presence of negative air ions but their performance in the positive ionized air was the same as those in normal air. Additionally, Positive and negative ionisation influenced the amplitude of the normal circadian rhythm of performance.

Charry and Hawkinshire (1981) examined the effect of positive air ions on galvanic skin response (GSR), reaction time and mood. The study was conducted on 85 subjects falling in an age range of 18–60 years with a mean age of 30. They designed a single blind experiment and examine individual differences in response to small positive air ions. Exposure of positive ions with a dose level 2.0-3.0x10^4 \text{ions/cm}^3 was given to the subjects for 1.5 hour. Air was delivered through large particles filter, electrostatic precipitator, temperature (22\(^\circ\)c), and humidity was regulated by vent system. Results were analysed by repeated measure F-test. Analysis of these data indicated that whereas mood changes were present for most subjects when exposed to positive ions, assessment of individual differences in susceptibility was essential for detecting effects on performance and physiological activation. For most
subjects, mood changes induced by positive ion exposure were characterized by increased tension and irritability. For susceptible (ion-sensitive) subjects, skin conductance measures showed depressed activation and reaction time increased during exposure to ions. For nonsensitive subjects, skin conductance measures revealed increased activation, with no effects of ions on reaction time. In other words, ‘ion-sensitive’ subjects showed that activation decreased and reaction times increased during exposure to positive air ions while nonsensitive subjects showed increased activation and no effects on reaction time. They found decrease in GSR, mood was affected and reaction time was not affected by the exposure of the lowest doses (2.0x10^4 ions/cm^3). However, the higher doses of positive ions (3.0x10^4 ions/cm^3) increased both the GSR and the reaction time. This is strongly an indicative of individual differences on ion sensitivity.

Hedge and Eleftherakis (1982) conducted two studies. In the first study, the influence of negative ions on alpha activity in EEG and simple reaction time was examined. The study was conducted on 8 males and 8 females. Fifteen were 17-18 years old and one was 20 year old. A repeated measure design was used. Results were analysed by analysis of variance repeated measure. The 2nd experiment tested the relationship between reported weather-sensitivity, susceptibility to migraine and change in performance of simple two-and-four choice reaction time with exposure to negative ions. 30 subjects were randomly assigned to two groups. Experimental group comprised of six males and 12 females subjects (aged between 20-43 years) and control group comprised of 6 males and 6 females (age 19-51 years). Results were analysed by Mann Whitney U test and ANOVA. For control sessions ions level were 390-550 negative ions cm^-3. For the first phase of experimental session these were 450-550 ions cm^{-3}, for second phase with ionization these rose to 9000-15000 ions cm^{-3} and in the post ionization phase levels were 400-1900 ions cm^{-3} for both experiments. No significant effects attributable to exposure to negative ions were found in either experiment.

An experiment was conducted by Baron and Dreher (1964) with negative air ions. The study was conducted on 10 male pilots with in an age range of 35 to 50 years. A double-blind study was done using repeated measure design. They measured psychomotor performance and biochemical responses. In psychomotor performances- brightness, reaction time, complex perceptual- motor task and muscular steadiness were measured whereas for biochemical responses- glucose, steroids and biogenic amines level was measured. Exposure of negative air ions was given for 1.25 hours with a dose level of 1.0x10^4ions/cm3. Results were analysed by F-test found no effect on any task and biochemical responses.
A duct system, through which air of controlled ion concentration was flowed, was used with a temperature of 17 degree Celsius by Bachman, McDonald and Lorenz (1966) using a factorial design. In series was chamber with a flexible dielectric floor which made possible electric detection of activity in rats. Exposure of negative and positive ions was given for 45 minutes with a dose level of $1.5 \times 10^6$ ions/cm$^3$. Exposure to various ion concentrations of either polarity produced pronounced effects. In addition to gross motor activity six other behavioural parameters were recorded. Activity of rats increased with both the ion polarities. However, there was also a decrease in the activity recorded with negative air ion exposure. In addition to presenting a controlled ambient ion concentration the ion current drawn by the animal was measured. This varied markedly from rat to rat, indicating large individual differences in the effect of ions.

Terry, Harden, and Mayyasi (1969) conducted a study in which they divided an equal number of 240 male and female rats of the King-Holtzman hybrid breed, into two age groups (group $A_1$: 21–30 days old and group $A_2$: 90–100 days old). They were exposed to two levels of noise: $N_0 = 30$ db and $N_1 = 90$ db, (Ref. 0.0002µ bar), and three levels of negative air ions: $I_0 =$ no measurable ion concentration, $I_1 = 7 \times 10^6$ ions/cm$^3$ and $I_2 = 7 \times 10^7$ ions/cm$^3$. Time and error scores of 240 rats running a modified Lashley left-right maze with an escape-from-water motive served as criteria. A randomized complete blocks design with replications ($2 \times 3 \times 2 \times 2 \times 10$) was selected for treatment by analysis of variance. The results indicate that (a) the males show significantly lower error score in negatively ionized air; and (b) the females swim significantly faster than males under all investigated conditions with no apparent effect of noise or ions on their performance.

In a study of geophysical variables and behavior, varied human performance in ionized air was studied by Farmer and Bendix (1982). Their main purpose was to investigate the claim that human performance may be enhanced by exposure to artificially high concentrations of negative air ions. 16 subjects were taken for this experiment. Only half of them were informed of the ion level in each session. Ss performed reasoning, psychomotor, and memory-search tasks. Adequate control of confounding variables was taken. No clear evidence was obtained in support of the view that negative ions in the air influence performance.

Buckalew, and Rizzuto (1984) investigated the effects of negative ions produced by a commercially marketed air purification device on grip magnitude, coding, motor dexterity,
reaction time, tracking, pulse, blood pressure, and temperature. Two groups of 12 males (20-30 years old) were exposed to 6 continuous hour of either negative or "normal" ion environments under a double blind condition. Repeated measures (0,3,6 h) on each variable were obtained. MANOVA applied to change scores revealed no differences between groups, and 0 vs. 3 and 0 vs. 6-h group differences showed no significant alteration in any measure. Negative ions generated by an air purification device were concluded to produce no general or specific alteration of cognitive or psychomotor performance or physiological condition.

In the following section the relationship of well being and personal comfort with negative air ion exposure is reviewed.

McGurk (1959) examined the effects of negative and positive air ions on self-reported feelings of comfort, ease of working on cognitive tasks, and reactions to the test room environment in 10 college-aged males. They were subjected to 5 hours at a specific work tasks under two conditions a) an environment of approximately 8000 negative air ions per cc of air b) the natural ion concentration of the test room. The same subjects also performed two hours of the same work in an environment of approximately 8000 positive ions per cc of air. All subjects were informed that on some days the air would be ionized; however, subjects remained uninformed about polarity. The task required that the subject place five differently coloured iron washers on a standard 5/16 inch bolt in a moderately complex pattern and fasten the nut securely. The findings showed that no statistically significant differences appeared among the three conditions. The subjects were asked also to report their feelings of bodily comfort, ease by which they worked, and the reactions to the test room atmosphere. These were classified as pleasant, unpleasant or neutral. The findings indicated that negative air ion exposure resulted in a notable increase in the proportion of subjects reporting more pleasant feelings, while positive air ion exposure versus the control condition resulted in a significantly higher reporting of unpleasantness.

Albrechtsen, Clausen, Christensen, Jensen, Moller (1978) conducted two single-blind experiments to evaluate the influence of negative and positive air ionization on subjective feelings among two groups under well-controlled conditions. In experiment I, 6 randomly-selected women (age range: 20–30) were individually exposed in a climatic chamber to high concentrations of positive atmospheric ions, negative atmospheric ions and no ions. Physiological measurements were made, mental performances were tested and subjective votings were recorded. Results indicated no significant effects of positive or negative
atmospheric ions. In Experiment II, 12 (7 male and 5 female) subjects (age range: 19–45) were selected out of 125 persons, all tested individually for feeling of discomfort when exposed to positive air ions in short selection experiments. Each subject participated in six 4-hour exposures. Two doses of each polarity High \((9.0 \times 10^3 \text{ ions/cm}^3)\) and low \((3.0 \times 10^2 \text{ions/cm}^3)\) were given for one day. These subjects were exposed twice to the same three ion conditions as in Experiment I. Friedman test and Wilcoxon test was used for statistical analyses. Outcomes included subjective assessments on feelings of self-exertion, stuffiness, the unpleasantness of cognitive tasks performed, and sleepiness. Across both studies, no significant effects were identified.

Hawkins (1981) conducted a study to assess the effects of ambient temperature, humidity and air ionization in an office environment on personal ratings of thermal comfort, stuffiness, alertness, and well-being. The incidence of headache, nausea and dizziness was also recorded. Temperatures above 23°C were associated with increased sensations of stuffiness, discomfort and unpleasantness, but appeared to produce a decrease in the number of complaints of headaches. A double-blind crossover experiment was conducted over 12 weeks. A total of 106 male and female subjects were asked to made daily records of their assessment of the environment and their health over a 12-week period. Subjects \((n=106)\) were divided into groups based on areas of variable ionization levels. Hawkins observed that the office environment was found to be depleted in small air ions. The negative air ionization increased the subjective rating of alertness, atmospheric freshness and environmental and personal warmth. Ions reduced the complaint rate for headache by 50% and also significantly reduced the number of complaints of nausea and dizziness. Night-shift working was associated with a very high complaint rate of both subjective discomfort and ill-health. Positive air ion effects were not explicitly discussed.

Finnegan, Pickering, Gill, Ashton, and Froese (1987) conducted a single-blind experiment on 26 adults working within 5 different rooms of an office building. In each room an EC 300 negative ion generator (Medion) was installed. The on/off light indicated that the machine was on throughout the study, but an internal switch activated the ionisers without the subjects knowing. The subjects completed a questionnaire daily for 12 weeks, using linear analogue scales to rate the environment and their personal comfort. Certain specific symptoms were also recorded—for example, headaches, lethargy, nausea, dizziness, and nasal, eye, and throat symptoms. After four weeks without ionisation the ionisers were activated in three of the rooms. After a further two weeks the ionisers in the other two rooms were activated. Once
activated the ionisers remained on for the rest of the study. The air conditioning was not adjusted during the study. The negative ion concentrations in each study room and in a control room were measured every fortnight by an experienced operator with a 134A Atmospheric Ion Analyser (Medion). The temperature and relative humidity were measured each morning and afternoon with a wet and dry bulb hygrometer. A more detailed thermal survey of temperature, relative humidity, radiant heat, and air velocity was performed once in each study room and in the control room during each part of the study. The mean negative ion concentration was 139/ml before the study and 1841/ml after activation (p<0.001). Results indicated no significant changes between the different stages of the study in the variables in the control room or any of the study rooms. But it was also observed that higher temperatures led to the environment being assessed as being hotter and stuffier and people feeling hotter, while relative humidity, varied from 31% to 54%, and found no significant effect of negative air ionization on personal comfort.

Lips, Salawu, Kember, and Probert (1987) performed a double-blind crossover trial to examine the effect of negative air ions on alertness in 18 normal healthy adults for a period of one month. They were exposed intermittently to enhanced concentrations of negative air ions in their working environments. Subjects worked in either room one with windows (natural ventilation) or room two with no windows (mechanically ventilated). Evaluations of well-being and perceptions of air quality were deduced from answers to a questionnaire completed two times a day by the subjects. After their exposure to enhanced negative air-ion concentrations, the subjects' assessments of both their own well-being and the quality of the environment improved significantly. Neither harmful effects of exposure to enhanced levels of negative air ions nor changes in perceived thermal comfort were detected. Lips, Salawu, Kember, and Probert (1987) observed that following exposure to enhanced negative air ions, subjects' feelings of drowsiness were significantly reduced within both rooms.

Batra (2008) conducted a study in two phases. First phase was conducted in city markets. The area with higher and lower positive air ions concentration were identified. The general well being on PGI well being scale and general health on PGI health inventory were found to be lower amongst those having their shops in positively air ions dominated areas. Second phase was conducted in bank. Ionizers were put on for an hour daily to give negative air ions exposure. The well being on PGI well being was observed to enhance the well being.
Assael, Pfeifer, and Sulman (1974) conducted a double-blind crossover study to examine the effects of negative air ions on relaxation and alertness among 10 healthy participants (age range: 20–65) and 10 subjects on tranquilizers. Exposure of 20 subjects to negative ionisation was monitored by EEG. Negative ionisation was supplied by an Ionotron apparatus with an output of $3.5 \times 10^5$/cm$^3$ at 1 m distance. Objective findings in ten normal subjects showed reduction of the frequency of the alpha-waves from 10 or 11 down to 9 or 8 Hz, increase of the amplitude by up to 20%, advance of the alpha rhythm pattern from the occipital to the frontal area and general synchronisation of the EEG records of both hemispheres. These reactions were suppressed in 10 subjects by tranquillisers. Subjective findings included relaxation, alertness, improved working capacity and relief from the Serotonin Irritation Syndrome produced by the positive ionisation of hot, dry desert winds. All patients reported an initial relaxation followed by alertness when exposed to negative air ions.

Negative air ions exposure not only reduce anxiety, depression or stress but is also associated with improved well being and comfort. Although inconsistency in results have been observed in this section. Studies conducted on learning, memory and attention are covered in the following section.

Olivereau and Lambert (1981) conducted an experiment in order to study the effects of air ions on some aspects of learning and memory of rats and mice. They conducted three experiments using different doses of both polarities. For experiment I and II independent three group design was used and for IIIrd experiment repeated measure design was used. In experiment I, a dose level of both the polarities ranging between $6.0-6.5 \times 10^5$ ions/cm$^3$ was given for 30 minutes. In the IIInd experiment dose of $8.0 \times 10^4$ ions/cm$^3$ was given for three weeks. In IIIrd experiment dose of $7.5 \times 10^5$ ions/cm$^3$ was given. However, exposure time was not reported in IIIrd experiment. Results of experiment I and II were analysed by Chi-square and that of IIIrd experiment were analysed by Mann-Whitney U test. They found that when submitted to a single avoidance task male mice showed different behavioral responses if previously treated with opposite aero ionization polarities. Whereas negative air ions tend to improve learning. Positive ions have disturbing effects. Male rats submitted to a single-trial inhibitory avoidance step-through task showed that retention processes may also be influenced by air ions. The positive ions treated animal exhibited signs of impaired short and long term memory. The slightly impaired score of negative air-ion treated animal seems only dependent upon the simultaneously increased locomotor activity. A separate experiment supported this hypothesis showing conspicuous differential effects of air ion polarity on
spontaneous activity of male rats. So exposure to positive ions impaired avoidance learning and exposure to negative ions improved it. Although positive and negative ions appeared to exert opposite effects on three indices of avoidance learning—latency to successful jumps, latency to escape, and ability to escape—on only one of these indices was there a difference between the ion-treated group and the control. For this index (latency to successful jump), the animals treated with negative ions had significantly shorter latencies than control animals, and there was no significant differences between control animals and those exposed to positive air ions. These did not differ from control animals.

Morton, and Kershner (1984) investigated the effect of increased concentrations of ambient negative air ions on incidental visual memory for words and purposive auditory memory for dichotic digits in 20 normal grade 4 children, 8 learning-disabled children, and 8 mildly mentally retarded children. Half in each group were assigned randomly to an unmodified air-placebo condition under double-blind testing procedures. After analysing the results it was found that all of the children breathing negatively ionized air were superior in incidental memory. In dichotic listening, the negative ions produced a counter-priming effect in the two learning-impaired groups, offsetting the difficulties that they showed under placebo in switching attention selectively from one ear to the other. The action of negative ions on the neurotransmitter, serotonin, may be the mechanism by which negative ions produce such behavioral effects.

Baron (1987b) examined the effects of negative ions on cognitive performance. Both male (56) and female (76) subjects participated in two studies. In experiment I, they worked on three different tasks (proof reading, memory span, word finding) in the presence of low (1.1x10^2 ions/cm^3), moderate (3.86x10^4 ions/cm^3) and high (7.81x10^4 ions/cm^3) concentrations of such ions. Subjects were randomly assigned to one of the three ion conditions. Proportion of men and women in each of these conditions was approximately constant. A 3x2x2 design was used. Results were analyse by F-test. Results indicated that among men performance on two tasks (proof reading and memory span) was enhanced by moderate but not high concentration of ions. In second experiment, undertaken to extend the generality of these initial results, male and female subjects performed two additional tasks (letter copying, decision making) in the presence of above mentioned three conditions of ions. Output of letter copying task increased significantly as ion level rose among both sexes with respect to decision making the tendency of male (but not female) participants to select initially preferred alternatives was significantly enhanced by moderate concentrations of
negative ions. The findings of these studies suggest that negative air ions can indeed exert appreciable effects on cognitive performance.

Morton, and Kershner (1990) experimented on differential negative air ions effect on learning disabled and normal achieving children. Forty normal-achieving (29 males and 11 females, mean age-11.91 years) and 33 learning disabled (LD) children (28 males and 5 females, mean age- 12.32 years) were assigned randomly to either a negative ion or placebo test condition. The levels of ions were $2.1 \times 10^{-4}\text{m/v-s}$. A dichotic listening task using consonant-vowel (CV) combinations was used. Results were analysed by using three way ANCOVA. Both groups showed an ion-induced increase in the normal right ear advantage (REA). However, the mechanisms for this effect were different for each group. The LDs showed the effect at the right ear/left hemisphere (enhancement). The normal achievers showed the effect at the left ear/right hemisphere (inhibition). The results are consistent with an activation-inhibition model of cerebral function and suggest a functional relationship between arousal, interhemispheric activation-inhibition, and learning disabilities. The LDs may have an interhemispheric dysfunction. Both groups showed superior right ear report and the normal achievers showed overall superiority. Normal achievers showed higher consonant intrusion scores, probably due to a greater cognitive capacity.

Andrade, Fernandes, Verghese and Andrade (1992) conducted a study to examine the effect of negative air ions on a range of psychological functions, from alertness to circadian rhythms. In a double-blind study planned to assess the effect of negative ions on cognitive performance in human volunteers, 65 female graduate course students were randomized into ionized atmosphere ($n = 34$) and control ($n = 31$) groups. The following cognitive tasks were administered: Digit Symbol Substitution Test, Addition Test, Visual Memory (Complex Figure) Test, Verbal Memory (Complex Passage) Test, Ideational Fluency Test and Clerical Speed and Accuracy test. Results were analysed by t-test. On all but the last two tests, the negative ion group performed significantly better (to a 15-40% extent) than controls. It is concluded that negative ionization of the atmosphere by artificial means may be of benefit in certain common, practical situation in which depletion of these ions.

Creim, Lovely, Weigel, Forsythe and Anderson (1995) measured taste-aversion (TA) learning to determine whether exposure high voltage direct current (Hvdc) static electric fields can produce TA learning in male Long Evans rats. 56 rats were randomly distributed into 4 groups of 14 rats each. All rats were placed on a 20 min./day drinking schedule for 12
consecutive days prior to receiving 5 conditioning trials. During conditioning trials, access to 0.1% sodium saccharin flavored water was given for 20 minutes, followed 30 minutes later by one of the four treatments. Two groups of 14 rats each were individually exposed to static electric fields and air ions, one group to +75Kv/m(+2x10^5 air ions/cm^3) and the other group to -75Kv/m(-2x10^5 air ions/cm^3). Two other groups served as sham-exposed control. Results showed that exposure to intense static electric fields and air-ions did not produce TA learning as assessed by this design.

Batra and Rashmi (1997) conducted a study in order to see the effects of negative ionic exposure on albino rats. For investigating the effect of negative ions on memory a multi-group design was employed. Four groups were taken that consisted of randomly selected male albino rats weighing 150 ± 5. One group was given no exposure (control group). Exposure of negative ionic environment was given for three different durations i.e. 45 min, 90 min and 120 min, before training them on a single trial passive avoidance task. The mean retention latencies for these four groups on retention test taken after 24 hours were 194.2, 19.4, 176.4 and 92.1 seconds respectively. The obtained results indicated that the retention was best in the animals given an exposure for 90 seconds. The results indicate that the presence of negative ions in the environment play a role in memory, in a dose dependent manner as higher duration led to a reduction in performance than the moderate duration.

Batra (2005) conducted a study on cognitive abilities amongst computer operators. The study was aimed to investigate the negative effects of positive ions on cognitive abilities. A 2x3 factorial design was employed to conduct the study by taking the subjects working and not working on computers for 1 year, 3 years, and 5 years. 60 subjects working in various institutions were selected on the basis of availability. To test the cognitive abilities, color stroop test and free recall learning tasks were employed. The results were analyzed by using 2 Way ANOVA. The results indicated no any significant effects of long years of working on computers on simple cognitive tasks.

Savita and Batra (2008) studied the effect of varied negative air ion exposure on learning and memory amongst the learning disabled. A 2 x 2 x 3 factorial design having three dose levels was used. A sample of 180 subjects was selected using McCarny learning liability evaluation scale. Three tasks i.e. digit span, serial learning, thirty word recall test were taken for learning and memory measurement. Results were analysed by three way ANOVA following DRT. All
the results showed beneficial effect of negative air ions on encoding, acquisition as well as retention.

Vinay and Batra (2010) studied the effect of varying levels of negative air ion exposure on psychomotor performances amongst mentally challenged population. A 3 x 4 x 4 pre post factorial design having three dose levels was used. A sample of 120 subjects with three groups i.e. mild, moderate and normal subjects were selected. Four tasks i.e. audio-visual reaction time, Crawford small parts dexterity test, Hand steadiness, Tapping test were used for measuring psychomotor performances. Results were analysed by three way ANOVA following DRT. All the results showed improvement in psychomotor performances amongst mentally challenged subjects.

Morton, and Kershner (1987) investigated the effect of high concentrations of negative air ions on a dichotic digits task in 19 mentally retarded individuals. Subjects were assigned randomly to an ion or to an unmodified-air placebo condition under double-blind testing. The ion density at the subjects face level was approximately 10000 small negative ions/cm$^3$. Left and right ears were precued for report order and this order was reversed for the second set of trials. Results were analysed using three way analysis of variance. Negative ions promoted greater left hemisphere lateralization on the first set of trials, and enhanced recall when switching to the opposite channels, in the second set of trials. However, they suggested that negative ions are not necessarily beneficial or detrimental to processing. Negative ions may increase arousal, in this case amplifying a time-phased, information processing disorder in the retarded characterized by excessive right hemisphere inhibition during early processing of receptive speech and diffuse inter hemispheric excitatory activation during later processing.

An experiment was done by Warm, Dember, and Parasuraman (1991) on performance and stress in a visual sustained attention task. 36 subjects (18 men and 18 women) from age range 18-30 years (mean age 26.6 years) were taken for the experiment. Subjects performed on a visual sustained attention (vigilance) task for 40 minutes during which they received periodic 30 seconds whiffs of pure air or a hedonically positive fragrance, Muguet or Peppermint, through a modified oxygen mask. Results were analysed by using F-test. The former fragrance had been independently judged as relaxing the latter as altering subjects who were receiving either fragrance detected significantly more signals during the vigilance task than unscented air controls. Subjective reports of mood and workload indicated that the Ss experienced the vigilance task as stressful and demanding. However, the fragrance had no
impact on the latter measures. These results provide the initial experimental evidence to indicate that fragrances can enhance signal detectability in a task demanding sustained attention, though the exact characteristics of effective fragrances have yet to be determined.

The consensus of the literature reviewed is that environmental air ion concentration levels and balance can affect a wide range of biological organisms, including humans. Although some studies have reported a variety of beneficial effects some have given unfavourable responses also. A few studies have shown that elevated negative air ion levels are widely reported to have beneficial effects on humans including enhanced feeling of relaxation, and reduced tiredness, stress levels, irritability, depression, anxiety and tenseness, improved learning and memory. Depleted ion levels and enhanced positive ion levels are reported to have no effect, or deleterious effects. So, with this background one may proceed toward the formulation of problem and hypothesis for the present study.